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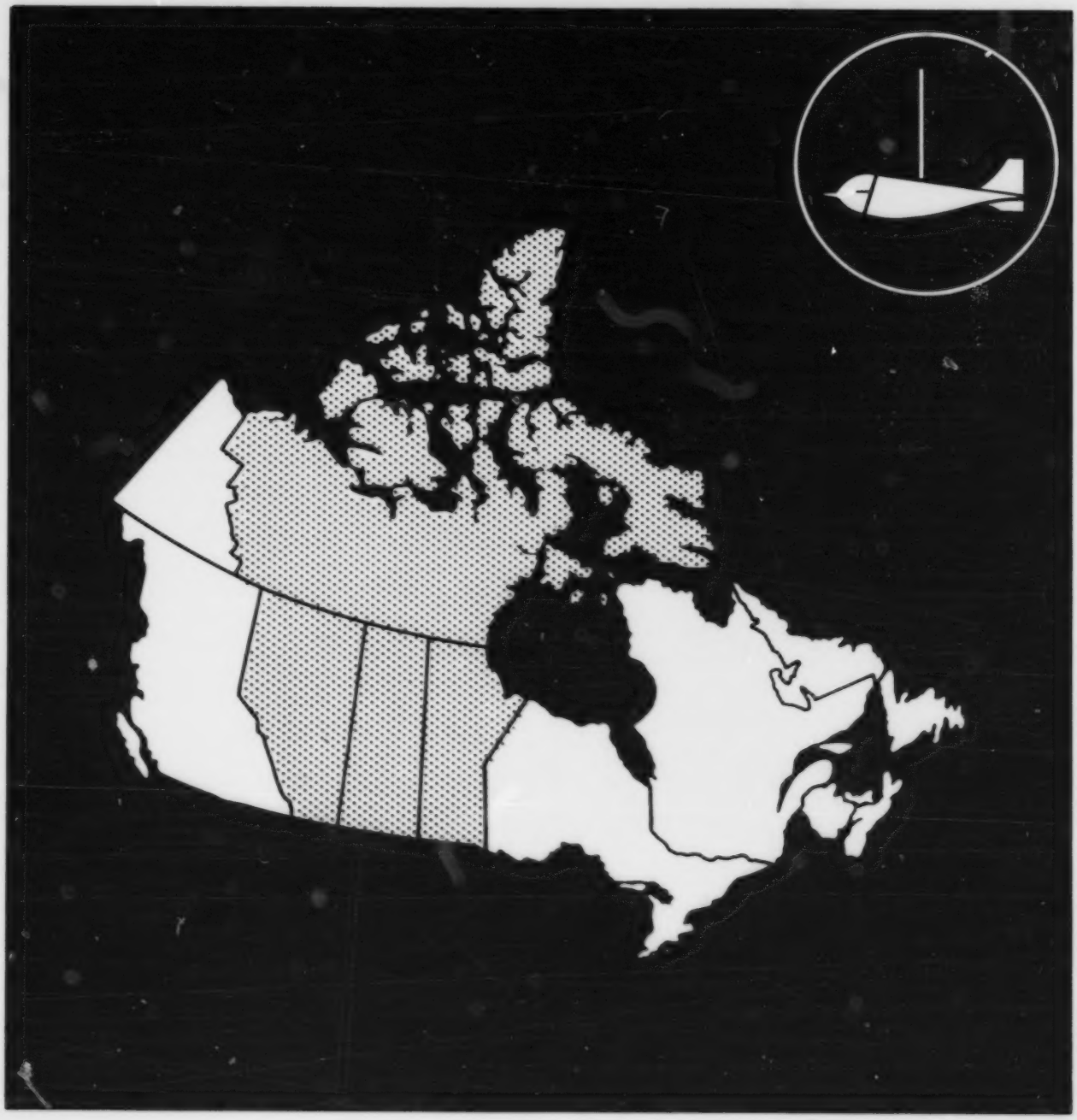
A REVIEW OF THE CURRENT (1988) MANITOBA SEDIMENT PROGRAM

T.R. YUZYK, F. PENNER



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A Review of the Current (1988) Manitoba Sediment Program

by

T.R. Yuzyk and F. Penner

Environment Canada

Manitoba Natural Resources

IWD-WNR(M)-WRB-SS-88-1

April 15, 1988

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Gentlemen:

We are pleased to submit "A Review of the Current (1988) Manitoba Sediment Program" by T.R. Yuzyk and F. Penner.

This major review of the jointly operated sediment program in Manitoba was initiated in 1986 by the Canada-Manitoba Hydrometric Coordinating Committee. Two previous reports arising from this review: "Proceedings of the Manitoba Sediment Issues Workshop: November 18-19, 1986, Winnipeg, Manitoba" by T.R. Yuzyk; and "A Compilation of Manitoba Sediment Data to 1985" by F. Penner, T.R. Yuzyk and R. Oshoway, were published and widely distributed in March, 1987, and January, 1988, respectively.

A draft of this report was presented to the Committee at its February 9, 1988, meeting in Winnipeg. The Committee agrees in principle with the recommendations put forth and has adopted this report as a guideline for managing the sediment program in Manitoba.

Respectfully submitted,

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1. INTRODUCTION

1.1 Background

In 1986, the Canada-Manitoba Hydrometric Coordinating Committee initiated a major review of the sediment network jointly operated by the provincial and federal Water Resources Branches. This review consisted of three distinct phases.

The first phase involved conducting a workshop to focus on the issues and data needs in the province. A multidisciplinary approach was taken in an attempt to broaden the scope of the existing program and to establish linkages among agencies needed to undertake integrated studies. The workshop was held in November, 1986, with the findings being documented in the workshop proceedings (Yuzyk, 1987).

For the second phase a major data compilation exercise was undertaken. This information was needed to help make sound technical decisions on the operation of the data collection programs at individual stations and to evaluate the network. The report (Penner, Yuzyk and Oshoway, 1987) was compiled and the data presented so that it would be useful to a broad range of users.

The third and final phase involved combining the information obtained from the first two phases and using it to make recommendations on the future and direction of the sediment program in Manitoba. This report completes this final phase.

1.2 Report Objectives

This report has been prepared to address the following objectives:

1) To provide a review of the data collection program being conducted at each sediment station;

2) To evaluate the effectiveness of the existing network in addressing sediment issues and data needs in the province; and

3) To put forth recommendations on changes which will enhance and improve the cost effectiveness of the sediment program in Manitoba.

1.3 Sediment Program (1987/88)

In 1987 a number of changes were made to the sediment program. One of the changes was the discontinuance of winter sampling at most of the sediment stations and sampling at the remaining few only if flows exceed a certain level (Glennie, 1986). With the high cost of particle-size analysis a system of checks was implemented for the laboratory to ensure that only samples providing meaningful information would be analyzed. Both of these changes have helped to make the program more cost-effective.

The program also has been expanded in terms of data collection capabilities. During the past year gravel bed sampling was introduced into the program following recently developed guidelines (Yuzyk, 1986). Two stations (Pembina River near Windygates and Valley River near Dauphin) were sampled during the fall, and other streams were identified for sampling in 1988.

A hydraulic/morphologic data collection program, as described by Northwest Hydraulic Consultants Ltd. (1986), was also initiated. A Level 1 survey was undertaken at the Roseau River at Gardenton site and a Level 2 survey at Red River at Emerson. These were pilot projects to determine the resources that would be required to obtain this information. The various users will have to be contacted to assess their needs with respect to these new data.

Data interpretation was more prominent as a number of station analyses (see Appendix A for example) were undertaken:

1. Pembina River near Windygates - Hydrocon Engineering (Continental) Ltd. - completed

2. Red River at Emerson - Glavic et al. - completed

3. Roseau River at Gardenton - Way - data analysis stage

4. Roseau River near Dominion City - Way - data analysis stage.

The program also focused on establishing a closer working relationship with the Water Quality Branch (WQB). The Pembina River at Windygates station analysis addressed water quality concerns with sediment data more extensively than any other analysis report previously. The Red River at Emerson station analysis is the first of three reports aimed at linking data/information collected by the two programs. The second report will compare WQB non-filterable residue and WRB suspended sediment data collected at this site. The final report is aimed at computing sediment-associated contaminant loadings in the Red River.

To further improve the program a Station Management Plan (see Appendix B) is being put into place in Manitoba to help guide the 1988 and future programs. The system, which is made up of tabular summaries and graphical outputs, will ensure that data are being reviewed, that standardized procedures are followed and that decisions are documented. It will also be useful in responding to graphical data requests, which were normally handled through headquarters.

Station profiles (see Appendix C) for the 20 active sediment stations have recently been completed. The station profiles provide information on the station, such as: data uses, station background and details of the sampling program. The profiles are intended to provide general information for managing the station.

Table 1 shows the 1987 preliminary sampling information for the 20 sediment stations where sampling was conducted.

Table 1. 1987 Sediment Sampling Program
(Preliminary Results)

Station Name and No.	No. of Suspended Sediment Samples	Particle-Size Analysis Depth-Integrating	Point-Integrating	Bed Material
1. Antler River near Melita. 05NF002	49	-	-	-
2. Assiniboine River at Headingly. 05MJ001	56	19	21	-
3. Assiniboine River at Holland. 05MH005	105	14	22	-
4. Burntwood River near the Elbow. 05TG004	2	-	-	-
5. Burntwood River near Thompson. 05TG001	8	-	-	-
6. Edwards Creek Drain Below Jackfish Creek. 05LJ047	124	12	-	-
7. Nelson River above Bladder Rapids. 05UD004	1	-	-	-
8. Odei River near Thompson. 05LF005	90	-	-	-
9. Pembina River near Windygates. 0508007	110	17	20	2 - Bulk Samples 2 - Grid Samples
10. Red River at Emerson. 050C001	260	34	27 (35)*	-
11. Red River Floodway near St. Norbert. 050C017	1	-	-	-
12. Red River near Lockport. 050J010	243	21	25	-
13. Red River near St. Norbert. 050C008	1	-	-	
14. Roseau River at Gardenton. 050D004	67	-	-	-
15. Roseau River near Dominion City. 050D001	130	-	-	-
16. Souris River at Wawanesa. 05NG001	77	5	-	-
17. Souris River near Coulter. 05NF016	84	-	-	-
18. Souris River near Lauder. 05NG025	93	-	-	-
19. Souris River near Minto. 05NG026	105	-	-	-
20. Valley River near Dauphin. 05LJ010	99	4	-	2 - Bulk Samples 2 - Grid Samples

* CONCENTRATIONS TOO LOW FOR 8 SAMPLES

2. REVIEW

2.1 Process of Station Evaluation

Where the objectives of a station are well defined, the data have been assessed according to how well the data collection program addresses the particular concern. In most cases, however, a station was established to define, in general, the sediment regime of a particular stream or river. Therefore, for these stations it was important to establish criteria which could be used to evaluate the data collection program and determine when sufficient information had been collected to document the sediment regime.

To describe the suspended sediment regime requires that data normally be collected over at least a 5 year span. During this span in the order of a several hundred samples will, in most cases, need to be collected. For most streams it is necessary to collect samples so that there are sufficient data to describe seasonal characteristics.

Once the temporal coverage has been assessed the sample coverage, as it relates to flow, is evaluated. A flow duration curve, which is usually based on a considerably longer period of record, is used to describe the flow regime at a site. The suspended sediment sampling program is put into perspective by assessing whether samples have been collected over the range of flows. If there are no gaps in the coverage, then the sampling program has been adequate.

Next it is necessary to determine how well the program documents high (peak discharge) flows. To do this a discharge frequency curve is used. Coverage is considered to be good when the highest sampled discharge peak corresponds to a peak whose probability of exceedance is less than 5%. This criterion would appear to be too stringent, but surprisingly this criterion was met at almost all the stations. Also, it is important that the range in annual peak discharges are covered as well.

Particle-size distribution of the suspended sediment is important for characterizing the sediment regime. A minimum concentration of ≈ 300 mg/L is needed to do a particle-size analysis, based on current laboratory procedures. This will result in the exclusion of data from streams where concentrations do not exceed 300 mg/L and severely restrict the number of samples that can be obtained at a site where this level is exceeded only for a short duration each year. Therefore, it would appear that it is not realistic to set a criterion for the number of samples that should be collected. However, for those streams where concentrations are relatively high, particle-size information should cover the range in concentration and discharge measured at that particular site.

Bed material is also an integral part of the sediment data collection program. In the past bed material data were collected using samplers primarily at sand bed sites, but occasionally on a gravel bed. Recently guidelines have been established for sampling fluvial gravels and they are now being incorporated into the program. This review

will identify possible sites where this type of sampling is needed. Since a major review of bed material sampling in sand bed streams is near completion, it seems premature to assess the adequacy of the bed material program. Sites where no data have been collected will however be identified for data collection using these new guidelines due in 1988.

2.2 Individual Station Reviews

Each station was reviewed following the process that has been described, and using information from the tables and figures (see Appendix D) which were put together for all 63 stations for the compilation report. The results of the individual station reviews are contained in Appendix E. This review primarily assesses the adequacy of the data collection program at individual sites. A more elaborate basin review, for the larger drainage basins, is needed to assess the value of the individual stations to the network.

In this review a few idiosyncracies in using the data base came to light. For instance, the historical file data are based on maximum sampled values, while the information on the main file, in many cases, has excluded these higher points as being anomalies. Likewise, concentrations from the particle-size file tended to be considerably higher than those on the main file, because they are based on instantaneous data rather than daily values. Both of these matters complicated reviewing the adequacy of the data collection program.

Not all the data collected as part of the sediment program were reviewed in this exercise. Point-integrating data were not assessed because of the limited amounts available and the fact that more elaborate procedures would be needed to properly assess this information. For similar reasons, bed load data have not been reviewed.

2.3 Station Network

During the 1980s, there has been a steady decline in the number of sediment stations being operated each year (Table 2). The number of full/seasonal stations has been declining, while miscellaneous stations have increased in number. For full/seasonal stations the sampling frequency is such that with some interpolation a period of record can be constructed. At miscellaneous stations samples are collected to allow use of extrapolative techniques (i.e. sediment rating curve).

The amount of data collected from year to year is highly variable as it is dependent on the hydrology. The discontinuance of the long-term Saskatchewan River at the Pas station prior to the 1987 field season explains the marked reduction in the number of sampled days in 1987.

This reduction (≃ 30%) in the network size can be attributed to a number of factors: past data collection has addressed some of the concerns; cutbacks owing to downsizing exercises in times of financial restraint; and to some degree, perceptions that there is little need for sediment data and that the program is too costly to operate.

Table 2. Sediment Station Network (1980-1987)

Fiscal Year	No. of Stations	Type of Program Full/Season	Miscellaneous	Calendar Year	No. of Days Sampled
1987-88	20	15	5		
1987-86	21	16	5	1987	< 1000*
1986-85	24	16	8	1986	1498
1985-84	24	18	6	1985	1573
1984-83	24	23	5	1984	1260
1983-82	28	24	6	1983	1512
1982-81	30	24	6	1982	1725
1981-80	28	24	4	1981	1293
1980-79	28	27	1	1980	1482

* 1987 ESTIMATED

It is hoped the economic climate will improve and add stability to the network. As for the perceptions, it is apparent from the Sediment Issues Workshop that there is a need for sediment information, but the existing program has to become more sensitive to these varied needs. Proposed changes to the sediment program put forth in this report will help in this matter. The past data collection program (primarily full time stations) was indeed very costly, but new measures such as the Station Management Plan and a shift towards miscellaneous stations are helping to make the program more cost-effective while still meeting the data needs.

2.3.1 Proposed Deletions

Based on the individual station reviews, numerous stations were identified as having sufficient data and, therefore, could be discontinued. It is proposed that the following stations be discontinued in 1988:

1. Antler River near Melita - 05NF002
2. Odei River near Thompson - 05TG003
3. Pembina River near Windygates - 050B007
4. Roseau River near Dominion City - 050D001
5. Roseau River at Gardenton - 050D004
6. Souris River near Lauder - 05NG025
7. Souris River near Minto - 05NG026
8. Valley River near Dauphin - 05LJ010

The Antler River and two Souris River stations were established to address environmental impacts of the proposed Garrison project and to derive a sediment budget for the Souris basin. Since development within the basin is no longer being pursued, there is little need to continue to collect data. The existing data also indicated that there are sufficient suspended data to document the sediment regime. Furthermore, two stations (Souris River near Coulter and Souris River at Wawanesa) are still operating and providing data on this basin. These stations also have considerable data, but should continue in operation until a basin analysis is done. These stations are needed to link information among the number of stations that have been operated in the basin.

A station analysis for the Pembina River near Windygates indicated that sufficient data have been collected to generally document the sediment regime. The report, recommends, however, that sampling of extreme high flows ($Q \geq 200$ m^3/s) and lower concentrations associated with discharge ($Q \geq 20$ m^3/s) should be targeted. While sampling of high flow is important to provide historical information, the value of low concentrations is not that apparent. Efforts to conduct comparative sampling in conjunction with the Water Quality Branch requires further follow-up. This concern should probably be addressed at an active rather than a discontinued site.

Both the Roseau River stations were set up to assess the effects of a proposed major land drainage scheme in the United States portion of

the basin. This development never materialized, but these stations continued to be operated. A review of the data indicates that ample data have been collected to document the sediment regime. Currently, station analysis reports are being prepared for each of these stations. It is felt that it is best to discontinue sampling so that the complete data base is covered in the review. Previous station analyses (Pembina River near Windygates and Saskatchewan River at the Pas) have subsequent years of data which were never included in the final analyses.

2.3.2 Proposed Additions

Limited data have been collected in the northern part of the province because systematic sampling is both difficult and expensive. However, the Northern Flood Agreement signed in 1977 by Canada, Manitoba, Manitoba Hydro and the Northern Flood Committee has resulted in a more concentrated effort being made to document sediment sources, transport and depositional areas along the Churchill River Diversion. Recent overview studies (see Section 2.5) indicate that our understanding of the sediment processes along the route is limited. It is therefore recommended that a 1- to 2-year intensive sampling program be initiated to help construct a more reliable sediment budget. The following sites are proposed for this intensive study:

1. Churchill River Diversion at South Bay (06EC002) - reestablish station
2. Rat River below Notigi Control Structure (05TF003) - reestablish station
3. Burntwood River below Three Point Lake - new station
4. Burntwood River below Wuskwatim Lake - new station
5. Burntwood River near Thompson 05TG001 - operating station
6. Burntwood River near Elbow 05TG004 - operating station

No sediment data exist on the larger streams draining into Hudson Bay. One of the responsibilities of the federal program is to monitor loadings into the marine environment, and as a past study (Binda, Day and Syvitski, 1986) notes, there are limited data being collected. It is therefore proposed that a miscellaneous sampling program, which is directed at sampling on an opportunity basis, be started to provide background level information. Four current hydrometric sites have been selected:

1. Seal River below Great Island (06GD001)
2. Churchill River above Red Head Rapids (06FD001)
3. Nelson River at Kelsey Generating Station (05UE005)
4. Hayes River below Gods River (04AB001)

The Sediment Issues Workshop identified the fact that the current program was not adequately addressing the needs of various users. The agricultural groups, for instance, are primarily interested in data from small streams which are sensitive to changes in land use practices. Currently there is an effort between PFRA and Manitoba Agriculture to develop a monitoring program to address land use changes and the effects of small headwater ponds in the Tobacco Creek basin. As this proposal is in the preliminary stages it is not possible to assess, at this point, the extent of the various agencies' involvement. It is probable that the South Tobacco Creek near Miami (05OF017) station will need to be reactivated. Conversations with C. Jenkins (Manitoba Agriculture) also identified an interest in sediment data from the following basins: Stony Creek, Birnie Creek, Medora Creek and Boyne River. A meeting should be organized with the various agencies (WRB, PFRA, MWRB, MA) to discuss details regarding an integrated study to address agricultural concerns.

Fisheries are also interested in sediment information to assess impacts of various channelization projects and drainage schemes. Concerns were expressed by J. O'Connor (Manitoba Fisheries) about impacts from work being done in Saskatchewan on the Carrot, Red Deer and Qu'appelle river systems. Attempts should be made to develop a suitable strategy which can address this interprovincial concern. Within the province a number of streams have been identified as fisheries concerns. In the Dauphin Lake area the Mink, Mossy and Turtle rivers are of interest; however, some data are available at all of them, at least enough to provide pre-project information. Another area of concern is the Interlake area. The Icelandic River at Riverton (05SC002) is an index station for fisheries in this area, and sediment data are considered to be a useful addition.

The individual station reviews identified a few stations that seem to have been discontinued prematurely. Some are still active hydrometric stations and therefore can be easily reactivated for sediment data collection. The Ochre River at Ochre River (05LJ005) sampling program did not cover the higher flow range ($\geq$ 45 m^3/s), and the particle-size coverage is poor. Both stations on the Whitemud River (05LL002, 05LL005) also have limited particle-size information. These stations should be reactivated as special event stations to collect this missing information and improve the data base.

The program should, over time, focus on providing good spatial coverage of sediment data. Efforts should be made to collect some preliminary data from areas where no data have been collected.

2.4 Sediment Studies

There are numerous studies that would enhance understanding of sediment transport in many areas of the province. In some cases (i.e. Red River Floodway and Portage Reservoir/Diversion route) a considerable amount of suspended sediment and cross-sectional data have been collected to document the effects of major developments, but these data have not been thoroughly analyzed and reported. The findings of these studies should be made more visible and widely distributed.

Numerous smaller-type morphological studies could also be undertaken. For instance, there are relatively large dunes in the Assiniboine River and very little is known about their rate of movement. A program to track these dunes would provide valuable information for such projects as the locating of the water intake for the La Salle diversion scheme. The effects of removing a major gravel bar upstream of the Holland site could also be studied.

There have also been a number of attempts to quantify bed load transport (i.e. bed load traps) in streams draining the escarpment. Other data can be obtained from records on dredging of ditches, drains, impoundments and delta development. A review should therefore be undertaken to compile this information and assess our understanding of bed load transport.

Hydraulic geometry relationships are important in the design of many projects. A major compilation should therefore be undertaken to develop these relationships for many basins in the province. Much of the information can be obtained from existing data, but it may also be necessary to supplement this with data from smaller tributaries to properly develop these relationships.

Sediment budgets for a drainage basin are a valuable extension of the information that can be derived from the station data (see Ashmore, 1986). A basin analysis provides a spatial review of the data base and helps assess the value of the network and consequently the value of individual stations. There are a number of basins in the province where considerable data have been collected and these should be analyzed using this approach. The basins are the Assiniboine, Red and Souris.

Another worthwhile exercise would be to produce a map to spatially depict sediment yield (Stichling, 1973) or other sediment characteristics. This type of presentation of the data is very popular, and with more than 25 years of data collection it is possible to produce a meaningful product.

2.5 Northern Flood Agreement

Much of the concern with sediment in the northern part of the province relates to the Churchill River Diversion. The initial phases of two studies addressing sediment concerns along the route were recently completed. One assesses morphological changes (Kellerhals Engineering

Services Ltd., 1987) and the other deals with changes in the sediment regime (Northwest Hydraulics Consulting Ltd., 1987).

The first phase of the morphological review focused on identifying areas where morphological assessments are needed (Table 3).

Table 3. Morphological Concerns along the Churchill River Diversion

River System/Section	Concern
Churchill (Southern Indian Lake to Notigi Reservoir)	- shoreline erosion and lake sedimentation resulting from increased water levels.
Churchill (below Southern Indian Lake)	- address morphological effects due to reduced flow regime.
Rat/Burntwood (Notigi Reservoir to Split Lake)	- morphological changes to the river channel due to increased flows - shoreline erosion in Wapisu and Three Point lakes - sedimentation in Split and Three Point lakes.
Nelson (Lake Winnipeg to Split Lake)	- morphological changes associated with 2- and 8-mile channels - sedimentation in Playgreen Lake - shoreline erosion in Kiskittogisu, Cross and Sipiwesk lakes due to increased water level.
Nelson (below Split Lake)	- morphological changes attributed to increased flows.

The next phase of this review is underway with the main focus on quantifying morphological changes at specific sites based on aerial photographs. Once this has been completed and the information has been assessed, the need for specific monitoring studies will be addressed.

The companion study deals with assessing changes in the sediment regime attributed to the diversion scheme. Sources and sinks for sediment, similar to those described in the morphological report, were identified. The report concluded that it appears, based on the limited data, that sediment concentrations have not increased; however, loadings are considerably greater (up to 10 times) because of the higher flows.

To improve our understanding and permit a more accurate sediment budget to be constructed three studies are proposed. The studies are:

1) compile remote sensing data to document sediment transfer through the system;

2) conduct a 1-year intensive sampling program to establish a sediment budget;

3) quantify depositional rates, by means of sediment traps, for the lakes along the system.

The next phase of this study will provide more detailed plans regarding these studies.

3. RECOMMENDATIONS

3.1 Provincial Implications

1) Data - the province has been involved in collecting their own suspended sediment data at various sites since the late 1970s. These data should be jointly reviewed to ensure they comply with the national standards of the WSC, and if so, the data should be incorporated into the WSC data base.

- WSC has expanded its data collection capabilities to include gravel bed material and morphologic/hydraulic data. The province should assess their future needs regarding these types of data.

ii) Data collection - work sharing should become more widespread if there is going to be an attempt to keep up with data demands.

- the province's sampling equipment should be checked and updated (i.e. plastic nozzles) so that it is compatible with WSC.
- provincial staff will need to be trained/updated in the sampling procedures used by WSC.
- provincial staff should be used more frequently to help with data collection, especially during critical times such as freshet.

iii) Data Management - a Station Management Plan has recently been developed and is being implemented by WSC. The province will have to assess this tool to see if it meets their perspective regarding data management.

iv) Data Interpretation - time-sharing should become as important as cost-sharing in operating this program.
- there is a growing need for sediment information (i.e. basin studies) which will require a larger role for interpretation.
- there is also a need to produce more interpretive reports to ensure that users/public/management are aware of the value of this program.
- the province should adopt the system of producing a station analysis report when discontinuing a provincial station.

v) Network - discontinuation of provincially funded stations:
Souris River near Lauder (05NG025),
Souris River near Minto (05NG026).
- discontinuation of jointly funded stations:
Odei River near Thompson (05TG003)
- reactivate discontinued stations as special event stations:
Ochre River at Ochre River (05LJ005),
Whitemud River at Westbourne (05LL002),
Whitemud River near Keyes (05LL005).

- activate/reactivate jointly funded stations:

  Churchill River at South Bay (06EC002),

  Rat River below Notigi Control Structure (05FF003),

  Burntwood River below Three Point Lake,

  Burntwood River below Wuskwatim Lake,

  South Tobacco Creek area,

  Interlake area.

3.2 Federal Implications

i) Data - the data collected by the province at a number of stations should be jointly reviewed with the province with the intention of incorporating these data into the WSC data base.
- gravel-bed sampling should be conducted at three stations this year in a continuing systematic effort to document gravel-bed streams in the province.
- hydraulic/morphologic data should be collected at another two sites in a continuing effort to obtain this information.
- bed material sampling in sand-bed streams will need to be reintroduced into the program following the guidelines due to be completed in 1988.

ii) Data Collection - provide training to provincial staff on sampling procedures.
- quality assurance in the data collection needs to be more rigorously applied.

- effort needed to coordinate sampling times with WQB so as to collect comparative data at NFA sites and Red River at Emerson (05OC001).
- effort should be made to collect comparative samples with the USGS at Red River at Emerson (05OC001).
- a number of stations:

  Red River at Emerson (05OC001)

  Red River near Lockport (05OJ010)

  are being oversampled. The sampling program should be cut back to 50-100 samples until an analysis is completed regarding the value of these stations.

iii) Data Management - implement Station Management Plan system.
- more effort is needed to establish quality control procedures when reviewing suspended sediment data.

iv) Data Interpretation - federal portion of program has to focus on producing internal interpretive reports.
- a basin analysis report for the Assiniboine, Red or Souris river system should be undertaken in the upcoming year.

v) Network - a technical committee made up of representatives from various agencies should be set up to guide program direction.

- discontinuation of provincially funded stations:

  Souris River near Lauder (05NG025),

  Souris River near Minto (05NG026).

- discontinuation of jointly funded stations:

  Odei River near Thompson (05TG003)

- discontinuation of federal stations:

  Antler River near Melita (05NF002),

  Pembina River near Windygates (050B007),

  Roseau River near Dominion City (050D001),

  Roseau River at Gardenton (050D004)

  Valley River near Dauphin (05LJ010)

- reactivate discontinued provincial stations as special event stations:

  Ochre River at Ochre River (05LJ005),

  Whitemud River at Westbourne (05LL002),

  Whitemud River near Keyes (05LL005).

- activate federal miscellaneous stations:

  Seal River below Great Island (05GD001),

  Churchill River above Red Head Rapids (06FD001),

  Nelson River at Kelsey Generating Station (050E005),

  Hayes River below Gods River (04AB001).

- activate/reactivate jointly funded stations:

  Churchill River at South Bay (O6EC001),

  Rat River below Notigi Control Structure (O5TF003),

  Burntwood River below Three Point Lake,

  Burntwood River below Wuskwatim Lake,

  South Tobacco Creek area,

  Interlake area.

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APPENDIX A

Sample Output of a Sediment Station Analysis

SEDIMENT STATION ANALYSIS
PEMBINA RIVER NEAR WINDYGATES
05OB007

IWD-WNR(M) - WRB-SS-87-2

Prepared for:
ENVIRONMENT CANADA
CONSERVATION AND PROTECTION
Inland Waters and Lands
Western and Northern Region
Water Resources Branch
Winnipeg District

Prepared by:
HYDROCON ENGINEERING (Continental) LTD.
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March 1987
File: 291-26.5

ABSTRACT

This is one of a series of sediment station analysis reports issued by the Water Resources Branch of Environment Canada. It presents a summary and analysis of the sediment data for the Pembina River near Windygates, Manitoba, (Sta. 05OB007), for the period 1962-1984. The data have also been assessed in terms of the use of sediment rating curves, water quality concerns, and reservoir sedimentation studies.

It has been concluded that the available sediment data on the Pembina River near Windygates sufficiently describe the present sediment regime, and that the detailed sediment data collection program should be suspended. It is recommended that a miscellaneous sediment data collection program be instituted, which could run in conjunction with a short-term water quality sampling program aimed at studying organic contaminant loading. The miscellaneous program should also aim to measure suspended sediment concentrations for extreme high and low flows, as well as particle sizes for low concentrations.

Table A.1 summarizes major sediment parameters derived from the data base.

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APPENDIX B

Station Management Plan Forms

STATION MANAGEMENT PLAN

STATION NO. _____

NAME: _____

LOCATION: Latitude _____
Longitude _____

SAMPLING STRATEGY:
_____ Continuous
_____ Seasonal
_____ Miscellaneous
_____ Special Event

DATA OUTPUT:
_____ Load
_____ Suspended Sediment Concentration
_____ Suspended Sediment Particle Size
_____ Bed Material
_____ Bed Load
_____ Dissolved Solids
_____ Temperature

STATION OBJECTIVE(S)

STATION NO. _____

HISTORICAL REVIEW

PART I - FLOW & CONCENTRATION DATA

1. Year Range ( ): ____ to ____

2. Total number of SSC Samples: _____

3. Number of SSC Measurements (5 vert.): _____

4. Max. ( ) flow, Q: _____ m^3/s

5. Min. ( ) SSC: _____ mg/L with Q: _____ m^33/s

6. Max. ( ) SSC: _____ mg/L with Q: _____ m^3/s

7. Gaps in Flow range of sample coverage: _____ to _____ m^3/s
   _____ to _____ m^3/s
   _____ to _____ m^3/s
   _____ to _____ m^3/s

PART II - SUSPENDED PARTICLE SIZE DATA

8. Total number of Depth Integrating Particle Size Samples: _____

9. Number of Depth Integrating Particle Size Measurements: _____

10. Number of Point Integrating Measurements: _____

11. Number of Point Integrating Samples: _____

12. Range in percent content; Clay/Silt: _____ to _____ %
    Sand: _____ to _____ %

13. Range of SSC (Particle Size): _____ to _____ mg/L

14. Range of Flow (Particle Size): _____ to _____ m^3/s

PART III - BED MATERIAL DATA

15. Number of Bed Material Samples: _____

16. Number of Bed Material Measurements: _____

15. Range of percent content; Clay/Silt: _____ to _____ %
    Sand: _____ to _____ %
    Gravel: _____ to _____ %

STATION NO. _____

ANNUAL REVIEW

REVIEWED BY: _____ YEAR: _____

PART I - FLOW & CONCENTRATION DATA

1. Total number of SSC Samples: _____
2. Number of SSC Measurements (5 vert.): _____
3. Min. ( ) SSC: _____ mg/L with Q: _____ m^3/s
4. Max. ( ) SSC: _____ mg/L with Q: _____ m^3/s
5. SSC Samples nearest freshet peak; Conc.: _____ mg/L
   with Q: _____ m^3/s
   Qpeak: _____ m^3/s
6. Number of SSC Samples on rising freshet limb: _____
7. Number of SSC Samples on falling freshet limb: _____
8. Flow range of SSC Sample coverage: _____ to _____ %

PART II - SUSPENDED PARTICLE SIZE DATA

9. Total number of Depth Integrating Particle Size Samples: _____
10. Number of Depth Integrating Particle Size Measurements: _____
11. Range in percent content; Clay/Silt: _____ to _____ %
    Sand: _____ to _____ %
12. Range of SSC (Particle Size): _____ to _____ mg/L
13. Range of Flow (Particle Size): _____ to _____ m^3/s

PART III - BED MATERIAL DATA

14. Number of Bed Material Samples: _____
15. Number of Bed Material Measurements: _____
16. Range of percent content; Clay/Silt: _____ to _____ %
    Sand: _____ to _____ %
    Gravel: _____ to _____ %

STATION NO. _____

WORK PLAN RECORD

1988 WORK PLAN

Supervisor: _____ Date: _____

Field Person: _____ Most Recent Data: _____

COMMENTS:

EVALUATION OF ____ WORK PLAN

Supervisor: _____ Date: _____

Field Person: _____

COMMENTS:

STATION NO. _____

PLOTS

1. Discharge vs
   Time (%) Data Equalled or Exceeded / Sample Coverage.
   UPDATED (YR): _____

2. Depth Integrating Particle Size vs. Percent Finer
   UPDATED (YR): _____

3. Bed material vs. Percent Finer
   UPDATED (YR): _____

4. Max. Annual Discharge vs.
   Recurrence Interval in Years
   UPDATED (YR): _____

5. Discharge/SSC vs. Time

6. Rating curve:
   SSC vs. Discharge

Daily Data	Instantaneous Data

STATION NO. _____

TABLES

Updated (YR)

1. Summary of Suspended Sediment Samples

2. Depth Integrating Particle Size Analysis of Suspended Sediment

3. Particle Size Analysis of Bed Material

APPENDIX C

Sediment Station Profile Example

SEDIMENT STATION PROFILE

NAME: PEMBINA RIVER NEAR WINDYGATES
WSC NO: 050B007

LOCATION 49 01 53 98 16 40

WRB DISTRICT: Manitoba - N.W. Ontario

COST-SHARE AGREEMENT CLASSIFICATION: F3

DATE INSTALLED: 1962
STATUS: ACTIVE X
DISCONTINUED

DATA OUTPUT:

Suspended sediment concentration	X
Load	X
Particle size	X
Bed material	X
Bedload	
Temperature	X
Dissolved Solids	X
Hydrometric	X

A. SUMMARY OF CURRENT USES

The 1977 sediment network planning report identified the following uses.

- determination of sediment discharge
- sediment chemistry for pesticides
- study of channel behaviour deposition
- flood control, water supply and watershed management

December, 1987

B. STATION BACKGROUND:

The station was originally established for Pembilier Dam studies. Suspended & bed material sediment data has been collected at this site. Bed material data collection was discontinued after 1981. Winter sampling was discontinued in 1987 and thereafter unless flows are greater than 4 m3/s.

C: PROGRAM SUMMARY

Length of record:

26 years

Equipment and Procedures:

A variety of samplers have been used at this site - P61, D49, DH48 and DH59.

Single and Multiple Sampling:

Single vertical is at mid point of X section at cableway. Multiple vertical sampling taken to develop K factors.

Sampling Strategies:

Five to ten suspended sediment measurements (1 PI and 4 to 9 DI) are taken as appropriate. First PI/DI right after ice free conditions if concentration above 300 mg/l.

Technician collects daily sediment samples at time of visit.

Regular program is:

- 2 - 3 samples/day during high peak flows
- 1 sample/2 days at medium flows
- 1 sample/week at low flows
- winter sampling at time of visit if flow greater than 4 m3/s.

Sample Coverage:

The minimum sampled discharge is 0m3/s (0mg/l) on January 29, 1963. The maximum sampled discharge is 317 m3/s (1000 mg/l) on April 26, 974. The maximum instantaneous flow is 326 m3/s on April 26, 1974. The sampled suspended sediment concentrations have varied from a minimum of 0 on January 29, 1963 at 0 flow to a maximum of 5800 mg/l at 27.6 m3/s on April 20, 1967.

APPENDIX D

Compilation Report Example Output

SUMMARY OF DATA FOR THE YEARS 1962 TO 1985 24 YEARS OF DATA

DRAINAGE AREA: 7500 km2

STATION: 05OB007 - PEMBINA RIVER NEAR WINDYGATES
WATER SURVEY OF CANADA DATA

LOCATION: SE13-01-07W
FLOW: REGULATED

AVERAGE CONCENTRATIONS IN MG/L (SAMPLED DAYS ONLY)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	#SMPL
1962	-	-	-	749	76	39	24	29	40	23	31	20	118	116
1963	30	0	128	136	110	286	113	42	94	42	52	12	142	104
1964	-	-	-	370	227	108	24	24	42	29	32	-	187	93
1965	-	-	-	730	408	220	80	18	38	23	36	37	258	130
1966	85	20	387	636	368	136	109	35	57	78	41	18	258	156
1967	13	27	271	1024	413	168	36	46	60	23	21	20	379	125
1968	41	-	561	110	61	48	55	189	244	142	66	26	161	147
1969	81	134	87	461	294	198	112	67	55	29	11	56	204	155
1970	156	128	96	903	334	327	278	104	51	56	146	187	318	153
1971	166	151	80	683	312	175	160	132	85	39	65	80	288	118
1972	129	108	205	775	294	107	97	142	64	24	53	95	319	114
1973	127	125	93	63	49	124	137	132	51	45	113	111	95	44
1974	119	134	137	1134	573	349	216	39	61	56	162	182	498	69
1975	93	48	115	671	761	262	156	26	36	23	77	88	427	86
1976	71	150	65	1147	643	149	60	36	40	89	94	-	601	66
1977	-	-	-	38	347	229	87	106	80	31	-	-	163	49
1978	-	-	73	669	168	52	31	22	18	16	55	51	302	78
1979	83	-	-	1417	753	270	178	44	44	16	-	72	625	70
1980	13	-	-	208	192	77	110	143	96	103	87	139	153	62
1981	-	42	59	112	291	57	72	55	9	9	7	78	99	65
1982	-	-	16	508	307	937	51	24	6	12	10	50	368	65
1983	157	196	35	764	239	55	15	5	8	11	-	8	342	59
1984	-	70	104	54	24	191	11	7	-	-	3	-	63	60
1985	-	-	723	462	68	20	14	150	14	12	15	7	303	77

DAILY STATISTICS FOR PERIOD:

MEAN	94	101	296	604	343	202	110	76	78	48	49	67	274	
DEV	57	60	340	555	293	296	107	84	78	43	38	53	379	
MIN	0	0	0	8	11	6	7	1	5	0	3	7	0	
MAX	185	196	1630	5800	2260	4660	724	641	314	224	162	187	5800	
#SMPL	25	22	89	486	466	322	253	224	180	119	50	25		2261

ANNUAL FIGURES ARE BASED ON ALL SAMPLED DAYS FOR THE PERIOD SHOWN.

#SMPL = NUMBER OF SAMPLED DAYS

SUMMARY OF DATA FOR THE YEARS 1962 TO 1985 24 YEARS OF DATA

STATION: 05OB007 - PEMBINA RIVER NEAR WINDYGATES
WATER SURVEY OF CANADA DATA

DRAINAGE AREA: 7500 km2

LOCATION: SE13-01-07W
FLOW: REGULATED

MONTHLY SUSPENDED SEDIMENT LOADS IN TONNES (RECORDED DATA)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1962	-	-	-	-	1217	457	101	174	270	70	29	45	-
1963	35	0	508	1347	1351	3687	619	356	446	91	25	2	8467
1964	0	0	0	6359	4717	1001	73	105	114	50	19	2	12440
1965	0	0	0	28537	21424	6124	940	80	223	105	100	88	57621
1966	65	3	6972	52331	22471	2907	1329	169	102	62	22	3	86436
1967	5	6	972	59339	22378	2766	191	45	3	32	15	5	85757
1968	1	0	9113	1261	376	92	80	1714	5915	3757	817	100	23226
1969	93	130	86	98890	34223	6722	2526	778	336	134	73	146	144137
1970	169	112	83	85453	47549	27394	13902	2049	478	344	356	197	178086
1971	117	101	72	112225	32148	6046	4261	2878	987	264	232	223	159554
1972	184	118	4361	73310	18095	3085	1317	1814	489	146	110	37	103066
1973	27	26	428	366	188	182	407	306	170	169	200	126	2595
1974	90	100	126	184560	160899	39750	6450	300	341	189	251	154	393210
1975	46	11	44	11828	64906	11314	1973	145	87	52	117	56	90579
1976	69	676	322	218767	63151	5083	612	111	78	118	48	2	289037
1977	0	0	5	71	1109	197	32	3	16	22	4	1	1460
1978	0	0	20	35679	5164	452	96	43	28	14	17	13	41526
1979	8	1	3	150342	181185	15732	4353	182	152	48	60	50	352116
1980	6	1	2	2302	808	110	13	16	7	15	32	20	3332
1981	0	30	442	1576	2149	89	61	13	1	2	3	4	4370
1982	0	0	25	15679	11519	24837	839	167	23	40	17	35	53181
1983	44	11	146	38157	7154	733	89	6	3	8	4	1	46356
1984	0	1	61	274	173	1238	12	1	0	0	0	0	1760
1985	0	0	19275	23667	1305	181	74	201	25	27	15	4	44774
SUM	959	1327	43066	1202320	704442	159722	40249	11482	10024	5689	2537	1269	2183086
%	0.0	0.0	1.9	55.0	32.2	7.3	1.8	0.5	0.4	0.2	0.1	0.0	99.4

MONTHLY SUMMARY:

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	41	57	1872	52274	30627	6944	1749	499	435	247	110	55	94917
DEV	56	142	4489	63074	48947	10539	3167	803	1218	771	182	69	112687
MIN	0	0	0	71	173	89	12	1	0	0	0	0	1460
MAX	184	676	19275	218767	181185	39750	13902	2878	5915	3757	817	223	393210

Total annual load calculated only for years having monthly loads for the period APR to SEP.
Monthly sums and percent by month include only those years having a total annual load.

MAXIMUM NUMBER MISSING DAYS PER MONTH = 0

SUMMARY OF DATA FOR THE YEARS 1962 TO 1985 24 YEARS OF DATA

STATION: 05OB007 - PEMBINA RIVER NEAR WINDYGATES
WATER SURVEY OF CANADA DATA

DRAINAGE AREA: 7500 km2

LOCATION: SE13-01-07W
FLOW: REGULATED

YEAR	MEAN CONCENTRATION (mg/L)	TOTAL SUSPENDED SEDIMENT LOAD (tonnes)	YIELD (tonnes/km2)	TOTAL DISCHARGE (dam3)	MAXIMUM DAILY DISCHARGE (m3/s)
1962	---	---	---	81000	45.6
1963	136	8467	1.13	62100	7.22
1964	213	12440	1.66	58300	9.15
1965	409	57621	7.68	141000	39.1
1966	480	86436	11.52	180000	48.1
1967	715	85757	11.43	120000	49.0
1968	206	23226	3.10	113000	18.7
1969	333	144137	19.22	433000	228
1970	455	178086	23.74	391000	104
1971	449	159554	21.27	355000	167
1972	437	103066	13.74	236000	45.9
1973	75	2595	0.35	34400	2.94
1974	598	393210	52.43	657000	317
1975	515	90579	12.08	176000	42.2
1976	843	289037	38.54	343000	116
1977	199	1460	0.19	7320	3.91
1978	457	41526	5.54	90800	30.9
1979	872	352116	46.95	404000	152
1980	169	3332	0.44	19700	9.25
1981	149	4370	0.58	29300	8.12
1982	380	53181	7.09	140000	44.9
1983	433	46356	6.18	107000	28.7
1984	88	1760	0.23	20000	8.61
1985	422	44774	5.97	106000	32.5
MEAN	393	94917	12.66	179372	64.9
DEV	223	112687	15.02	166822	79.2
MIN	75	1460	0.19	7320	2.94
MAX	872	393210	52.43	657000	317

TOTAL SUSPENDED SEDIMENT LOAD AND TOTAL DISCHARGE CALCULATED FOR YEARS WITH COMPLETE DATA FOR THE MONTHS APR TO SEP.

MEAN CONCENTRATION = TOTAL LOAD DIVIDED BY TOTAL DISCHARGE

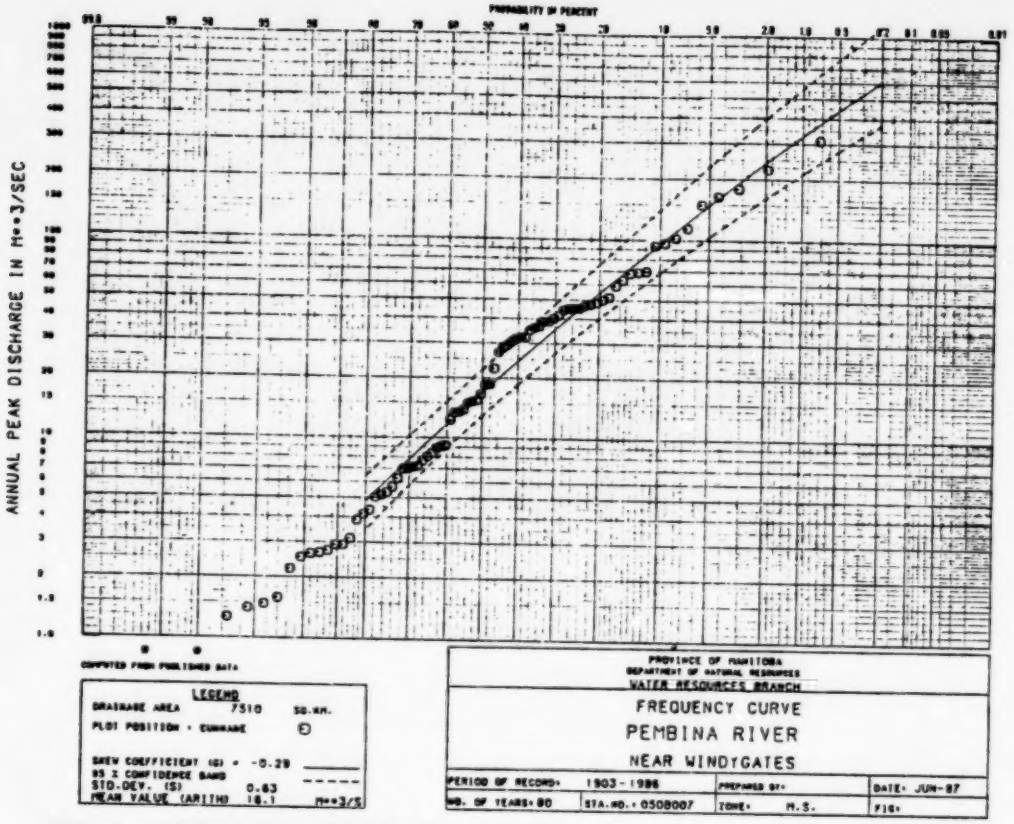

FIG. 1 DISCHARGE FREQUENCY CURVE

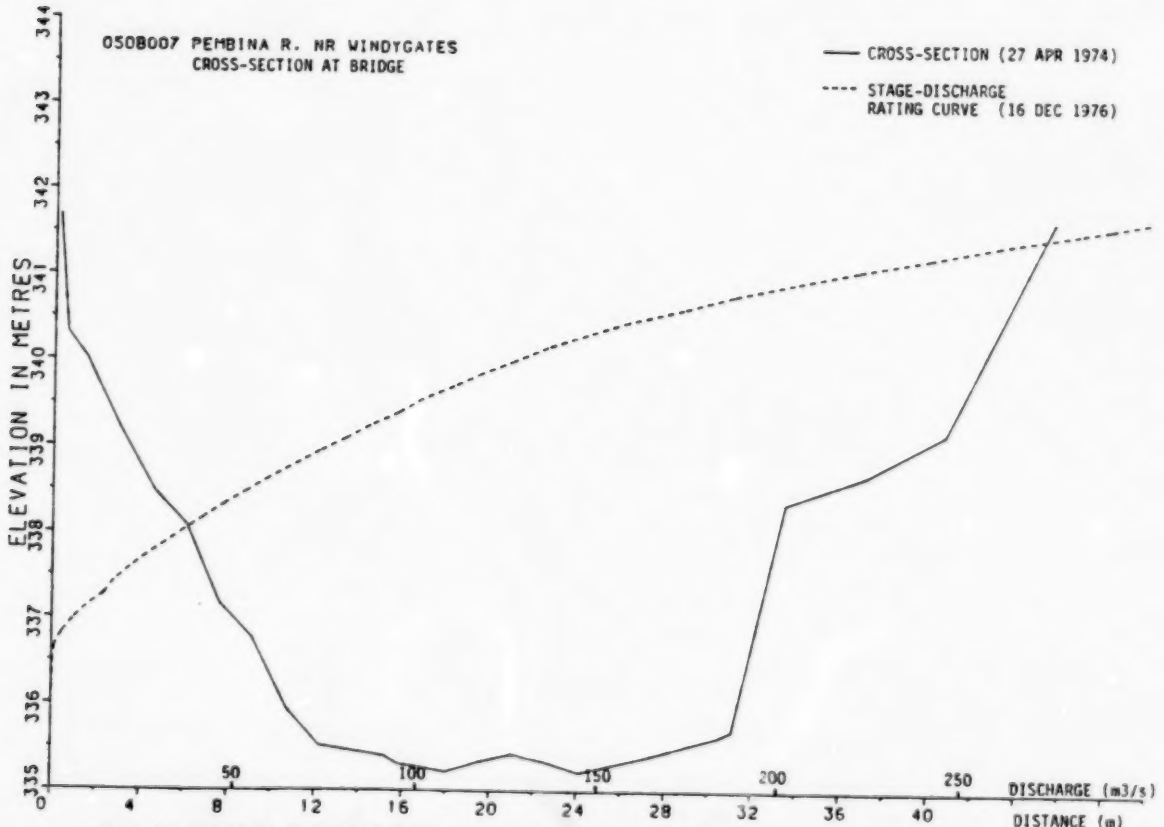

FIG. 2 STAGE-DISCHARGE RATING CURVE AND CROSS-SECTION

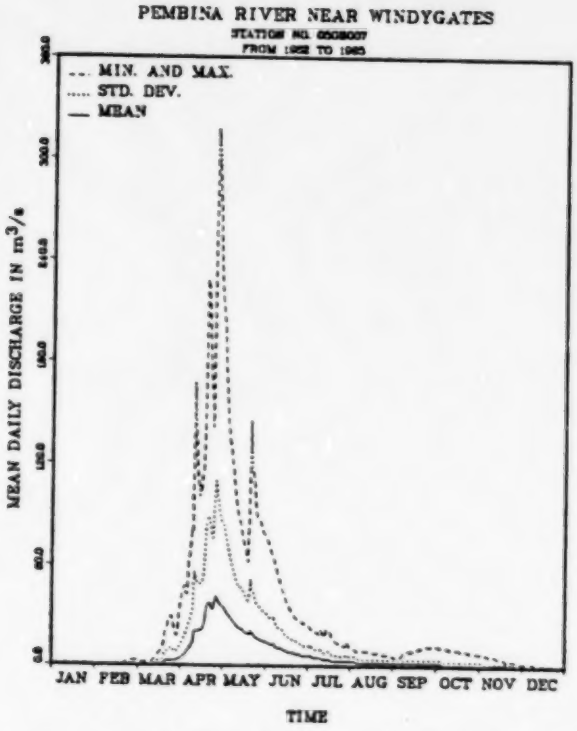
PEMBINA RIVER NEAR WINDYGATES
--- MIN. AND MAX.
..... STD. DEV.
— MEAN
MEAN DAILY DISCHARGE IN m³/s
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
TIME

FIG. 3 MEAN HYDROGRAPH AND DISCHARGE SUMMARY

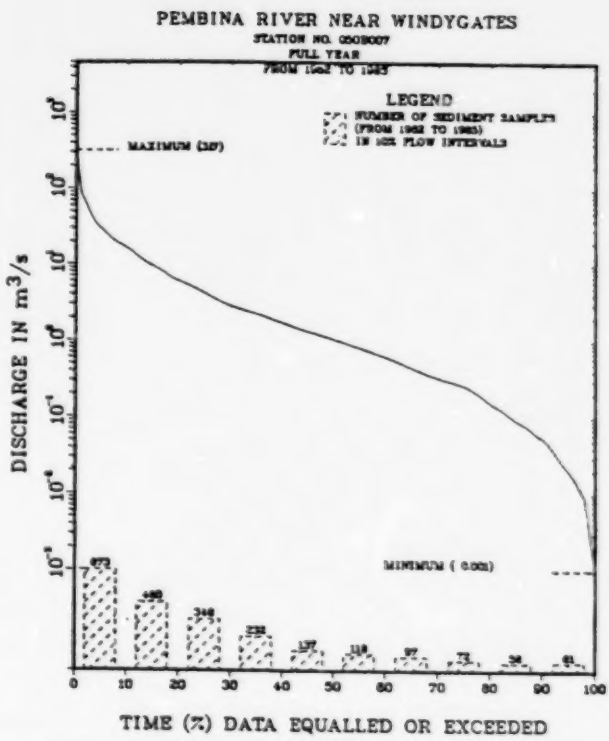

FIG. 4 FLOW DURATION CURVE AND SEDIMENT SAMPLE COVERAGE

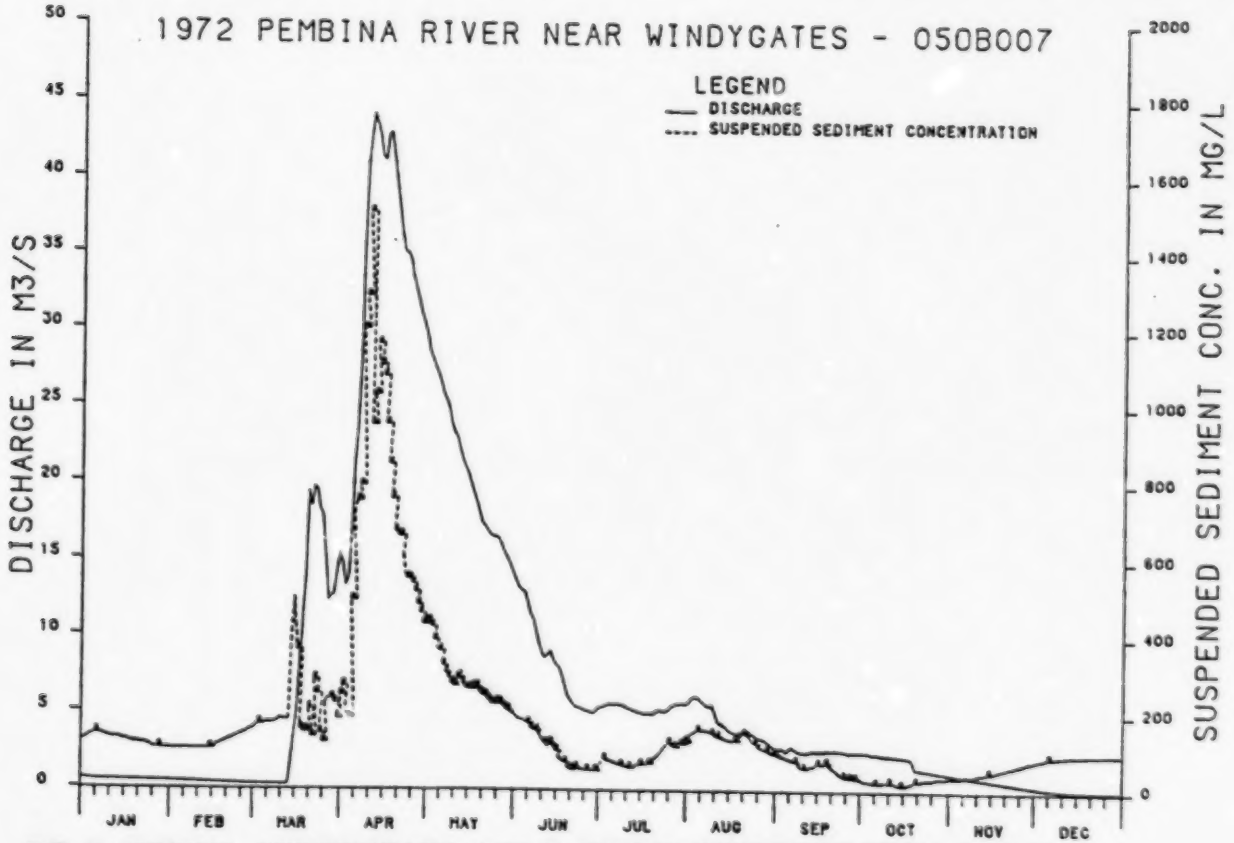
1972 PEMBINA RIVER NEAR WINDYGATES - 050B007
LEGEND
— DISCHARGE
---- SUSPENDED SEDIMENT CONCENTRATION
DISCHARGE IN M3/S
SUSPENDED SEDIMENT CONC. IN MG/L
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

FIG. 5 TYPICAL HYDROGRAPH AND SEDIMENT CONCENTRATION CURVE

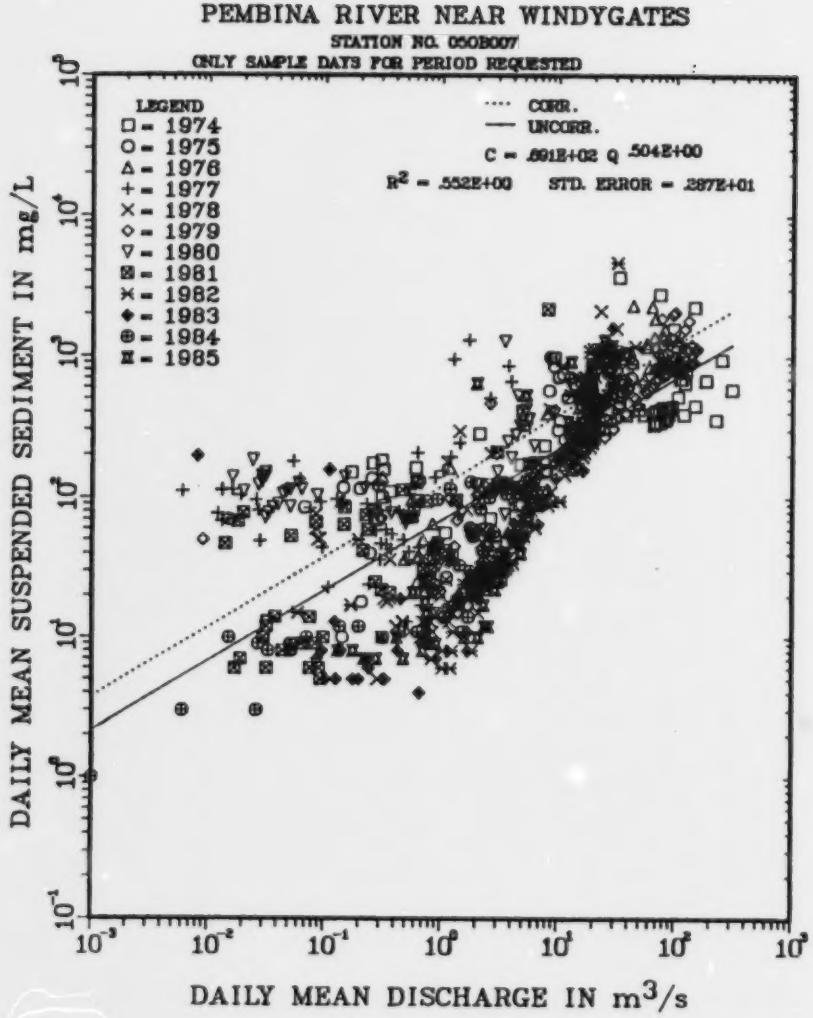

FIG. 6 SUSPENDED SEDIMENT VERSUS DISCHARGE (LOGARITHMIC SCALE)

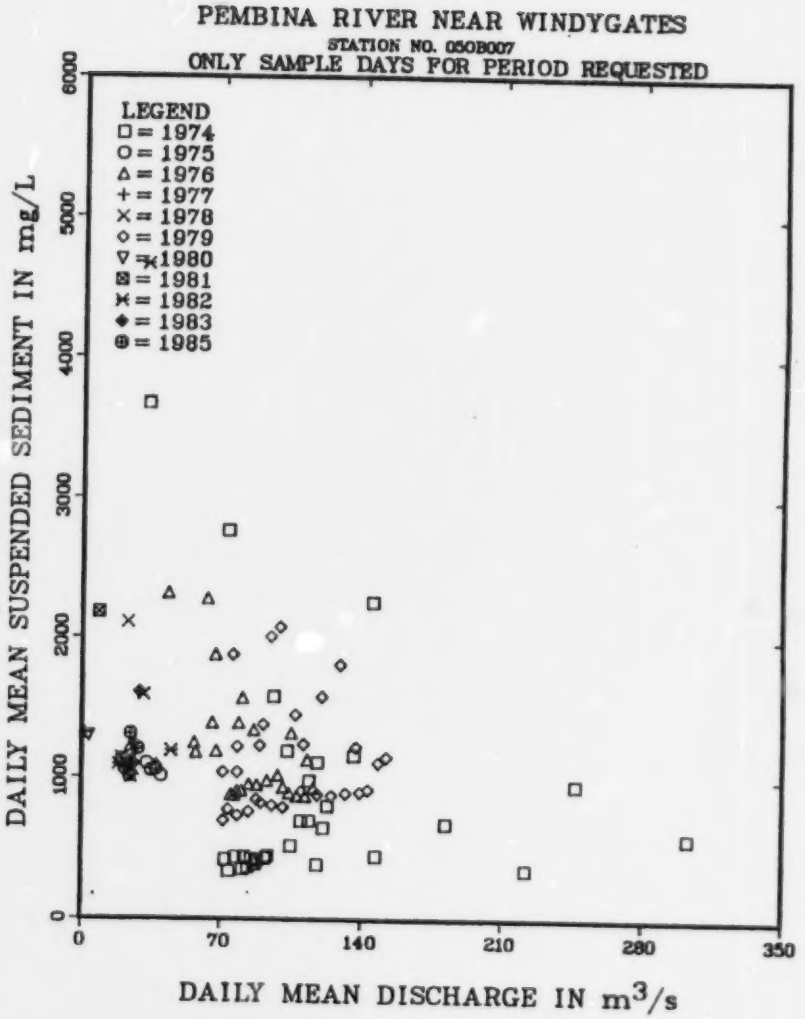

FIG. 7 SUSPENDED SEDIMENT VERSUS DISCHARGE (ARITHMETIC SCALE)

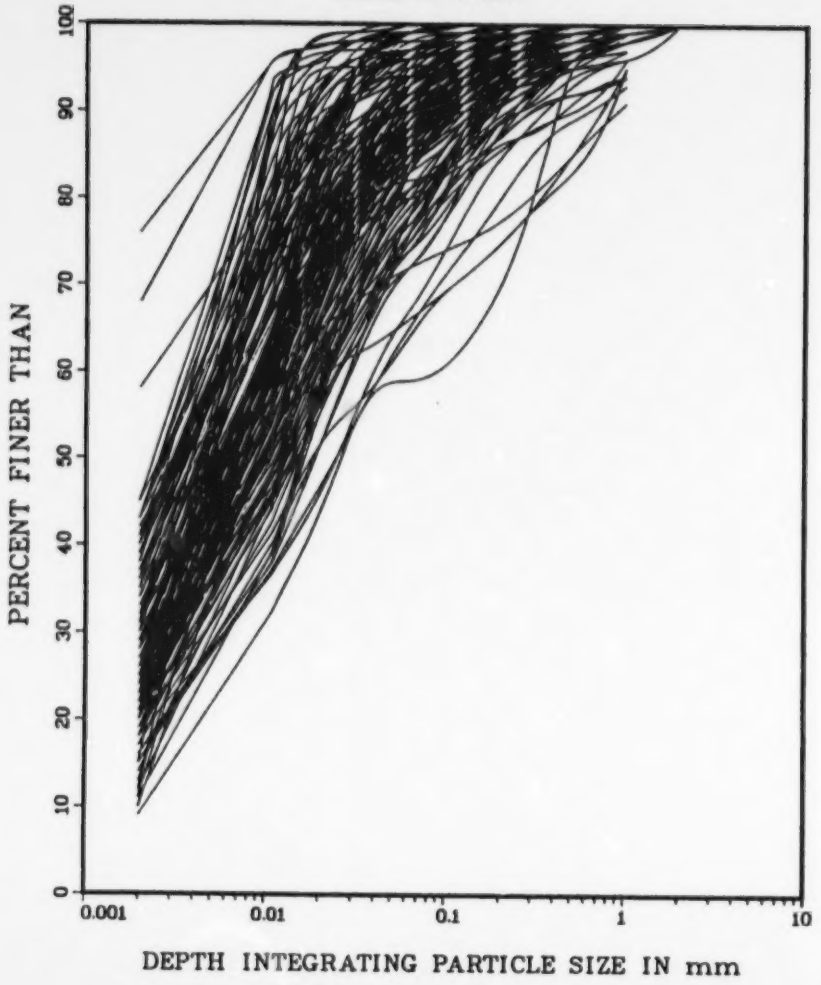

FIG. 8 SUSPENDED SEDIMENT PARTICLE-SIZE DISTRIBUTION

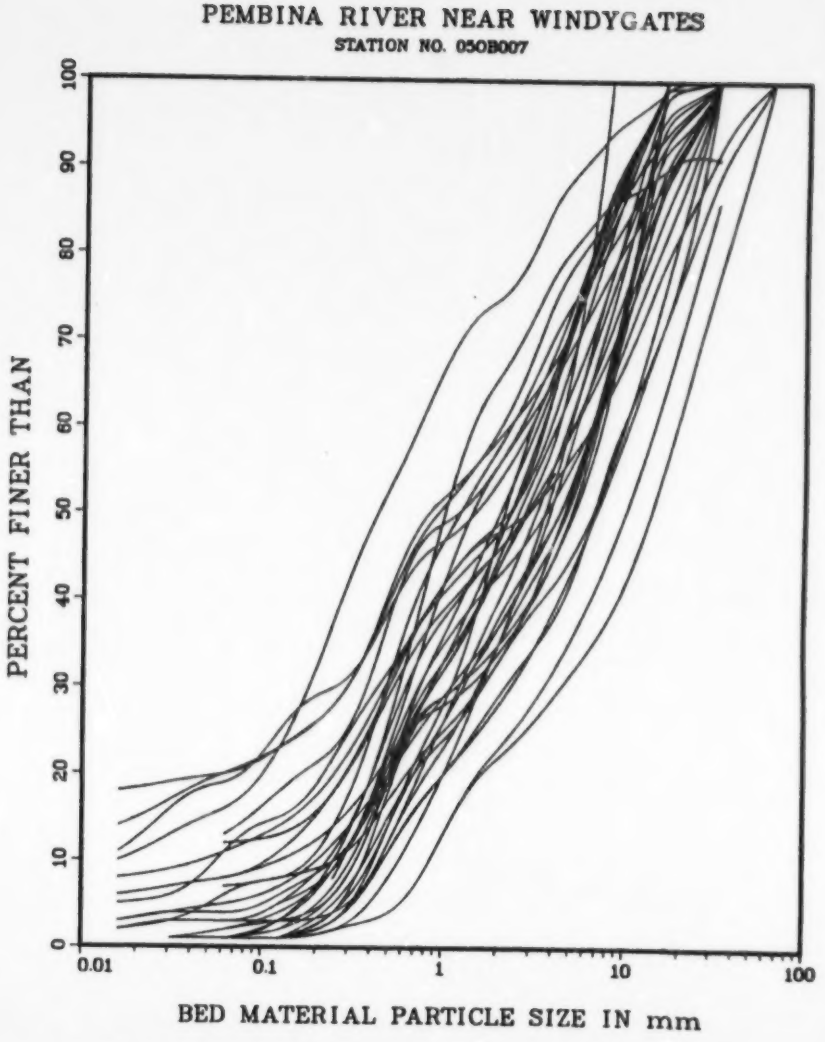

FIG. 9 BED MATERIAL PARTICLE-SIZE DISTRIBUTION

APPENDIX E

Individual Station Reviews

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Antler River Near Melita 05NF002	1976-1987	447	0 - 177	None	None	- Numerous suspended data - Range of daily flows covered - Good peak coverage (p<1.5%) - Concentrations too low for particle size analysis - No bed material data.	- Collect bed material data - Discontinue station - Station analysis - Basin analysis.
Station Objectives: International station to address the effects from the proposed Garrison Diversion. Note - project was never completed.							
Assiniboine River at Headingly 05MJ001	1956-1959, 1961-1987	2 516	4 - 2 270	232	62 (322)	- Extensive suspended data have been collected - Range of daily flows covered - Good peak coverage (p<1.0%) - Particle size covers range of concentrations (up to C=2 260 mg/L) - Extensive no. of bed material samples, data indicates a sizeable amount of gravel.	- Gravel bed sampling - Station analysis - Basin analysis.
Station Objectives: To address impacts from various projects on the Assiniboine River system: reservoirs, diversions and flood control.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Assiniboine River near Holland 05MH005	1970-1987	1 622	6 - 2 670	64	19 (23)	- Significant suspended data have been collected - Daily flow range covered - Good peak coverage (p<2.0%) - Particle size covers range of concentrations, up to C=2 890 mg/L. Note: considerabe scatter in data - Gravel bed reach - morphologic data required to assess removal of a major gravel bed.	- Gravel bed sampling - Impacts of gravel bar removal should be assessed.
Station Objectives: To determine sediment loadings into Portage Reservoir (1970).							
Assiniboine River near Portage La Prairie 05MJ003	1956-1959, 1961-1979	2 209	6 - 3 080	177	64 (322)	- Extensive suspended data have been collected - Daily flow range covered - Good peak coverage (p<2.0%) - Particle size covers portion of range of concentrations, up to C=2 600 mg/L.	- Station analysis - Basin analysis.
Station Objectives: To address impacts from various projects on the Assiniboine River system: reservoirs, diversions and flood control.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Assiniboine River near Rossendale 05MJ005	1970-1973	351	26 - 1740	22	8 (40)	- Discontinued because it was a poor hydrometric site.	- Include in basin analysis.
Station Objectives: To determine sediment loadings into Portage Reservoir (1970).							
Assiniboine River near Russel 05ME001	1969-1976	859	1 - 437	1	None	- See 1985 MWRB Report.	- Include in basin analysis
Station Objectives: To assess impact of Lake of the Prairies (1971).							
Burntwood River above Three Point Lake 05TE001	1977-1983	321	11 - 133	None	None	- See 1979 MWRB report, not very large contribution to the system.	
Station Objectives: To determine a sediment budget for the Churchill River Diversion.							
Burntwood River near the Elbow 05TG004	1978-1979	6	29 - 47	None	None	- See 1979 MWRB report, discontinued because of very low concentrations - Data only of limited value as there are only 6 samples.	- NFA proposed sediment budget study.
Station Objective: To determine a sediment budget for the Churchill River Diversion.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Burntwood River near Thompson 05TG001	1970-1979, 1981, 1987	422	5 - 75	None	1 (5)	- Discontinued due to low concentrations showing little variability - Numerous sediment data - Suspended sediment data does not cover range in daily flows - Good peak coverage ($p<0.1\%$).	- NFA proposed sediment budget study.
Station Objectives: To determine a sediment budget for the Churchill River Diversion.							
Churchill River above Leaf Rapids 06EB004	1975	2	8 - 10	None	None	- Discontinued due to low concentrations - Data of limited value as there are only 2 samples.	
Station Objectives: To determine a sediment budget for the Churchill River Diversion.							
Churchill River Diversion at South Bay 06EC002	1977-1981	108	4 - 43	None	None	- Low concentrations - No discharge data.	- NFA proposed sediment budget study.
Station Objectives: To determine a sediment budget for the Churchill River Diversion.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Edwards Creek Drain below Jackfish Creek 05LJ047	1979-1987	539	3 - 6 613	56	None	- See 1982 MWRB report - Significant samples collected - Discharge only available since 1980, therefore no historical perspective - Particle size covers range of concentrations up to C=6 040 mg/L - No bed material data.	- Bed material data needs to be collected - Can probably be discontinued, as 1979 marks a historical high for most area streams - Station analysis - Review MWRB (1983) data to incorporate into WSC data base.
Station Objectives: Erosion rates from the Escarpment and sedimentation in Dauphin Lake.							
Edwards Creek near Dauphin 05LJ022	1969, 1971-1979	557	2 - 11 200	135	2 (14)	- See 1982 MWRB report - Significant samples collected - Range of peak flows not fully covered (p<8%) - Particle size covers range of concentrations up to c=12 500 mg/L - Gravel bed needs proper sampling - Discontinued hydrometric station.	- Collect bed material - Station analysis.
Station Objectives: Erosion rates from the Escarpment and sedimentation in Dauphin Lake.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
La Salle River near Elie 05OGOX1	1978	25	1 - 239	None	None	- No discharge data - Limited sediment data.	- Reference MWRB data base.
Station Objectives: Sediment loads in the La Salle River.							
Mink Creek near Sifton 05LJ048	1979-1983	93	2 - 2 231	None	None	- See 1982 MWRB report - Fair number of suspended samples - Flow coverage weighted to higher flows - Good peak coverage (p<4.0%) - Missing particle size and bed material data - Discontinued hydrometric station.	- Collect bed material data.
Station Objectives: Erosion rates from the Escarpment and sedimentation in Dauphin Lake.							
Mossy River below outlet of Dauphin Lake 05LJ025	1979-1983	171	2 - 635	None	None	- See 1982 MWRB report - Fair number of suspended sediment samples - Range of flows covered - Fair peak coverage (p<6.0%) - Concentrations too low (only 1 sample above limit) for particle size - No bed material data.	- Collect bed material data - Review MWRB (1979, 1983) data to incorporate into WSC data base.
Station Objectives: Determine sediment loadings out of Dauphin Lake.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Nelson River above Bladder Rapids 05UD004	1978, 1987	3	14 - 24	None	None	- Limited sediment data.	- Collect sufficient data to characterize the sediment regime.
Station Objectives: Sediment budget for Nelson River and impact of Lake Winnipeg Regulation.							
Norquay Channel near Brunkild 05OF0X1	1978	24	11 - 386	None	None	- No discharge data - limited sediment data.	- Reference MWRB data base.
Station Objectives: Determine sediment load transported in the channel.							
Ochre River at Ochre River River 05LJ005	1979-1983	348	5 - 6 925	15	None	- See 1982 MWRB report - numerous suspended sediment samples - Range of daily flows covered - Very poor peak coverage (p<22.0%) - Particle size covers concentrations only up to C=1 730 mg/L - No bed material data.	- Re-activate as a special event station (target flows $\geq$45 m^3/s) for concentrations and particle size - Collect bed material data - Review MWRB data (1979,1983) to incorporate into WSC data base
Station Objectives: Erosion rates from the Escarpment and sedimentation in Dauphin Lake.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Odei River near Thompson 05TG003	1979-1987	545	10 - 182	None	None	- Numerous suspended sediment samples - Range of daily flows covered - Flow record only as long as sediment record, no historical perspective - Concentrations too low for particle size - No bed material data.	- Collect bed material data - Continue program until Burntwood budget study completed.
Station Objectives: Determine Odei River sediment contribution to Burntwood River system.							
Packhorse Creek near McCreary 05LJ034	1962-1975	519	0 - 10 700	72	2 (6)	- Numerous suspended sediment samples - Range of flows covered - Fair peak coverage ($p<6.0\%$) - Particle size covers range in concentration up to C=17 600 mg/L - Gravel bed stream - Discontinued hydrometric station.	- Collect gravel bed material data - Station analysis.
Station Objectives: Erosion rates from the Escarpment, linked with Wilson Creek experimental station.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Pembina River near Windygates 0508007	1962-1987	2 487	0 - 5 800	211	34 (166)	- See 1987 WRB report.	- Discontinue station - Analyze gravel bed material results.
Station Objectives: International station to monitor sediment transport.							
Portage Diversion Route							
05LL0X1	1974-1979	143	56 - 2 685	None	None	- See 1979 MWRB report.	- Reference MWRB data base - Included in basin analysis - Morphological study to report findings.
05LL0X2	1974-1979	127	43 - 2 756	None	None		
05LL0X3	1974-1979	144	43 - 2 857	None	None		
05LL0X4	1974-1979	121	29 - 1 325	None	None		
05LL0X5	1974-1979	165	41 - 2 524	None	None		
Station Objectives: To examine aggradation/degradation along the Diversion route.							
Portage Diversion Oakland 05LL018	1970-1976, 1979	274	58 - 3 420	30	7 (35)	- Numerous suspended sediment data - Good coverage of diversion flows - Fair particle size coverage of concentration range up to C=2 390 mg/L - Gravel bed material - Discontinued hydrometric site.	- Gravel bed sampling - Review MWRB (1974-1976) data to incorporate into WSC data base - Include in basin analysis - Morphological study to report findings.
Station Objectives: To quantify the sediment loads through the diversion.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Portage Diversion near Portage La Prairie 05LL019	1970-1979	207	36 - 1 500	33	None	- Fair number of suspended sediment data - Good coverage of diversion flows - Good particle size coveraged of concentration range up to C=1 660 mg/L - No bed material data	- Include in basin analysis - Morphological study to report findings.
Station Objectives: To quantify sediment loads through the diversion.							
Rat River below Notigi Control Structure 05TF003	1978-1979, 1981	7	5 - 18	None	None	- No flow data - Limited sediment data.	- NFA proposed sediment budget study.
Station Objectives: To determine sediment budget for the Churchill River Diversion.							
Red River at Elm Park Bridge 050C003	1956-1958, 1961	40	34 - 1 910	14	None	- No flow data - Limited sediment data.	- Include in basin analysis.
Station Objectives: To quantify sediment load transported by the Red River.							
Red River at Emerson 050C001	1956,1961	1 240	6 - 1 680	73	5 (22)	- See 1987 WRB report.	- Reduce sampling program to 50-100 samples per year - Basin analysis.
Station Objectives: International station to monitor sediment transport							

Individual Station Evaluation

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Red River at Selkirk 050J005	1956-1958, 1961,1974	45	44 - 1 470	14	None	- No flow data - Limited sediment data.	- Include in basin analysis.
Station Objectives: Sediment loadings into Lake Winnipeg and design of various projects.							
Red River at Winnipeg 050J001	1956-1959, 1961	22	60 - 1 180	22	None	- No flow data - Limited sediment data.	- Include in basin analysis.
Station Objectives: Sediment loadings into Lake Winnipeg and design of various projects.							
Red River Floodway near Birds Hill 050J0X1	1974-1976, 1978-1979	109	31 - 1 552	None	None	- No flow data - Limited sediment data.	- Reference MWRB data base - Morphological study to report findings.
Station Objectives: To assess aggradation/degradation in Red River Floodway.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Red River Floodway near Lockport 050J014	1969-1976, 1978-1979, 1987	182	44 - 3 160	56	9 (47)	- Fair number of sediment data - Range of flows covered - Good coverage of diversion flows - Particle size covers range in concentration up to C=2 870 mg/L - Predominantly gravels - Discontinued hydrometric station.	- Basin analysis - Morphological study to report findings - Review MWRB (1974-1976) data to incorporate into WSC data base.
Station Objectives: To quantidy sediment loads being discharged from the floodway.							
Red River Floodway near St. Norbert 050C017	1969-1979, 1987	211	66 - 2 500	59	10 (52)	- Fair number of suspended sediment data - Range of flows covered - Good coverage of diversion flows - Particle size covers range in concentration up to C=3 440 mg/L.	- Continue as a special event station (target flows $\geq$ 1 200 m^3/s) for concentration and particle size - Basin analysis - Morphological study to report findings - Review MWRB (1974-1976, 1978-1979) data to incorporate into WSC data base.
Station Objectives: To quantify sediment loads being diverted from the Red River through the floodway.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Red River near Lockport 050J010	1962-1987	3 808	1 - 2 450	157	None	- Extensive suspended sediment data have been collected - Range of daily flows covered - Probably peaks well covered, as 1979 was a major flood - Particle size covers range of concentrations up to C=22 870 mg/L - No bed material data.	- Collect bed material data - if designated as a key station, then cut back sampling program to 50-100 samples per year - Station analysis - Basin analysis.
Station Objectives: Sediment loadings into Lake Winnipeg and assessing impact of Red River Floodway.							
Red River near St. Norbert 050C008	1967, 1969-1976, 1977, 1978-1979, 1987	232	78 - 1 860	48	10 (48)	- Fair number of samples collected - Range of flows covered - Good coverage of peak flows - Particle size covers range in concentration - Particle size covers range in concentration up to C=3 390 mg/L.	- Continue as a specific event station to coincide with Floodway - Basin analysis - Morphological study to report findings.
Station Objectives: To assess loads transported by the Red River through the City of Winnipeg.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Roseau River at Gardenton 0500004	1972-1987	1 346	1 - 322	None	None	- Station analysis (presently being done) - Significant suspended sediment data - Range of flows covered - Range of peak flows not fully covered (p<8%) - Concentrations too low for particle size - No bed material data.	- Collect bed material data - Discontinue station - Basin analysis.
Station Objectives: To assess the effects from a proposed major land drainage scheme. Note: project cancelled.							
Roseau River near Dominion City 0500001	1972-1987	1 689	6 - 514	2	None	- Station analysis (presently being done) - Significant suspended sediment data - Range of flows covered - Good peak coverage (p<5.0%) - Particle size information is adequate (low concentration range) - No bed material data.	- Collect bed material data - Discontinue station - Basin analysis.
Station Objectives: To assess the effects from a proposed major land drainage scheme.							
Saskatchewan River at the Pas 05KJ001	1954-1960 1962-1986	3 383	6 - 1 130	152	60 (338)	- See 1986 WRB report - Bed material contains gravels.	- Gravel bed sampling.
Station Objectives: To evaluate changes in the Saskatchewan River basin (long-term station).							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Seine River Diversion near St. Adolphe 050E013	1972-1979	430	0 - 3 770	6	None	- Numerous suspended sediment samples - Range of daily flows - Good peak coverage (p<3.0%) - Particle size does not cover range in concentrations C=1 990 mg/L - No bed material data.	- Collect bed material data - Station analysis - Basin analysis.
Station Objectives: Assess impacts from the Seine River channelization project.							
Seine River Diversion near Ste. Anne 050H008	1973-1979	327	0 - 2 480	4	None	- Numerous suspended sediment samples - Range of daily flows - covered - Good peak coverage (p<3.0%) - Particle size only covers range of concentration up to C=1 560 mg/L - No bed material data.	- Collect bed material data - Station analysis - Basin analysis.
Station Objectives: Assess impacts from the Seine River channelization project.							
Souris River at Melita 05NF001	1976	47	16 - 187	None	None	- Data important as 1976 marks historical flood.	- Review these MARB data to incorporate into WSC data base - Include in basin analysis.
Station Objectives: Station to address effects from the proposed Garrison Diversion and to determine a basin budget.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Souris River at PR #454 near Hartney 05NG0X1	1976	45	14 - 107	None	None	- Data useful as 1976 marks historical flood.	- Reference MsRB data base - Include in basin analysis.
Station Objectives: Assess impact from proposed Garrison Diversion and to determine a basin budget.							
Souris River at Wawanesa 05NG001	1976, 1986-1976, 1980-1987	695	4 - 937	10	None	- Numerous Suspended data - Range of daily flows covered - Good peak coverage (p<2.0%) - Particle size covers range of concentrations C=984 mg/L - No bed material data.	- Collect bed material data - Review MsRB data (1976) to incorporate into WSC data base - Station analysis - Basin analysis.
Station Objectives: Assess impact from proposed Garrison Diversion and determine Souris River contribution to the Assiniboine River sediment budget.							
Souris River near Coulter 05NF016	1976-1987	809	4 - 477	4	None	- Numerous sediment data - Range of flows covered - Good peak coverage (p<3.0%) - Particle size data collection the best as can be expected C=262 mg/L - No bed material data - Inverse sediment rating relationship.	- Collect bed material data - Review MsRB data (1976) to incorporate into WSC data base - Station analysis - Basin analysis.
Station Objectives: International station to monitor sediment transport and assess impact from proposed Garrison Diversion and to determine a basin budget.							

Individual Station Evaluation

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Souris River near Lauder 05NG025	1976, 1983-1987	479	8 - 94	None	None	- Numerous suspended sediment data - Limited hydrometric record, therefore no historical perspective - Concentrations for particle size analysis - No bed material data.	- Collect bed material data - Review MWRB data (1976) to incorporate into WSC data base - Discontinue station - Station analysis - Include in basin analysis.
Station Objectives: Assess impact from proposed Garrison Diversion and to determine a sediment budget for the Souris River basin.							
Souris River near Minto 05NG026	1976, 1983-1987	484	5 - 340	1	None	- Numerous suspended sediment samples - No flow data - No bed material data.	- Collect bed material data - Review MWRB data (1976) to incorporate into WSC data base - Discontinue station - Include in basin analysis.
Station Objectives: Assess impact from proposed Garrison Diversion and to determine a Sediment budget for the Souris River basin.							
Souris River near Treesbank 05NG0X2	1976	48	19 - 1 514	None	None	- Data useful as 1976 marks historical flood.	- Reference MWRB data base - Include in basin analysis.
Station Objectives: Assess impact from proposed Garrison Project and to determine a Sediment budget for the Souris River basin.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Souris River near Westhope 05NF012	1956-1959, 1974-1976	102	5 - 318	None	None	- Limited number of samples - Daily flows not well covered - Good peak coverage (p<2.0%) - Concentrations too low for particle size analysis.	- Review MWRB data (1976) to incorporate into WSC data base - Include in basin analysis.
Station Objectives: International station to monitor sediment transport.							
South Tobacco Creek near Miami 050F017	1963-1977	1 230	0 - 9 340	144	6 (30)	- Significant number of suspended sediment samples - Daily flow range coverage - Flow range covered - Fair peak coverage (p<7.0%) - Particle size covers of concentrations up to C=20 400 mg/L - Bed appears to be becoming more gravelly.	- Special event station (target flows $\geq 18\ m^3/s$) - Gravel bed sampling - Proposed pilot study addressing agricultural concerns.
Station Objectives: Sediment yield from a predominantly agricultural basin.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Taylor River near Thompson 05TG002	1971-1979	431	7 - 224	None	None	- Numerous suspended sediment samples - Upper range of daily flows covered ($Q \geq 2\ m^3/s$) - Good peak coverage ($p<4.0\%$) - Concentrations too low for particle size - No bed material data.	- Collect bed material data - Station analysis.
Station Objectives: Sediment contribution to the Burntwood system.							
Turtle River near Laurier 05LJ007	1966-1982	1 079	0 - 5 210	141	7 (30)	- See 1982 MWRB report - Significant suspended data - Range of daily flows covered - Good peak coverage ($p<5.0\%$) - Particle size covers range of concentrations up to C=6 320 mg/L - Gravel bed.	- Gravel bed sampling - Station analysis.
Station Objectives: Erosion rates from the Escarpment and sedimentation in Lake Dauphin.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Valley River near Dauphin 05LJ010	1979-1987	531	1 - 780	18	None	- See 1982 MWRB report - Numerous suspended sediment data - Flow range covered - Good peak coverage (p<2.0%) - Particle size covers concentrarion range up to C=577 mg/L	- Analyze gravel bed material results - Review MWRB data (1983) to incorporate into WSC data base - Continue for another year - Station analysis.
Station Objectives: Erosion rates from the Escarpment and sedimentation in Dauphin Lake.							
Vermillion River near Dauphin 05LJ012	1970-1983	856	0 - 4 480	249	None	- See 1982 MWRB report - Numerous sediment data - Daily flow range covered - Good peak coverage (p<2.0%) - Particle size covers concentrations range up to C=5 660 mg/L - No bed material data.	- Collect bed material data - Review MWRB data (1979, 1983) to incorporate into WSC data base - Station analysis.
Station Objectives: Erosion rates from the Escarpment and sedimentation in Dauphin Lake.							

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Whitemud River at Westbourne 05LL002	1971-1979	992	4 - 2 970	2	1 (2)	- Numerous sediment samples - Daily flow range covered - Good peak coverage (p<4.0%) - Poor particle size coverage as highest concentration is only 456 mg/L - Gravel bed.	- Gravel bed sampling - Reactivate to improve particle size coverage - Station analysis - Basin analysis.
Station Objectives: Escarpment erosion rates and Whitemud sediment regime.							
Whitemud River near Keyes 05LL005	1971-1979	847	1 - 3 080	5	1 (5)	- Numerous sediment samples - Daily flow range covered - Good peak coverage (p<4.0%) - Poor particle size coverage as highest concentration is only 491 mg/L - Gravel bed.	- Gravel bed sampling - Reactivate to improve particle size coverage - Station analysis - Basin analysis.
Station Objectives: Escarpment erosion rates and Whitemud sediment regime.							

Individual Station Evaluation

Station Name and No.	Record Period	No. of Sampled Days	Range in Concentration (mg/L) (Excludes 1987 Results)	No. of Particle Size Measurements (Depth Integrated)	No. of Bed Material Measurements (Samples)	Program Evaluation	Recommendations
Wilson Creek near McCreary	1962-1980	974	0 - 18 800	200	19 (120)	- Numerous samples collected - Range of daily flows covered - Good peak coverage (p<3.0%) - Particle size cover range of concentrations - Gravel bed.	- Station analysis.
Station Objectives: International Hydrologic Decade experimental watershed to document erosion rates from an Escarpment stream.							
Wilson River near Dauphin 05LF011	1979-1983	203	1 - 1 721	10	None	- See 1982 MWRB report - Fair number of suspended sediment samples - Range of flows covered - Good peak coverage (p<4.0%) - Particle size covers range of concentration up to C=733 mg/L - Bed material data needs to be collected.	- Collect bed material data - Review MWRB data (1979,1983) to incorporate into WSC data base - Station analysis.
Station Objectives: Erosion rates from the Escarpment and sedimentation in Dauphin Lake.							
Winnipeg River Head Water Seven Sisters Power Plant 05PF057	1977	2	6 - 11	None	None	- Limited samples, only 2 - Low concentrations - Not a hydrometric station.	
Station Objectives: Background concentration levels.							